Imaging at the Nanoscale
ELEC 571

Overview

This is a part seminar and part lecture course that surveys the techniques used in imaging submicron and nanometer structures with an emphasis on applications in engineering, chemistry, physics, biology, and materials science. The course includes an introduction to scanning probe microscopy, scanning and transmission electron microscopy, and near field and super resolution optical microscopy. Included in this course will also be discussions on the fundamental and practical aspects of digital image acquisition, processing, analysis, and artifacts.

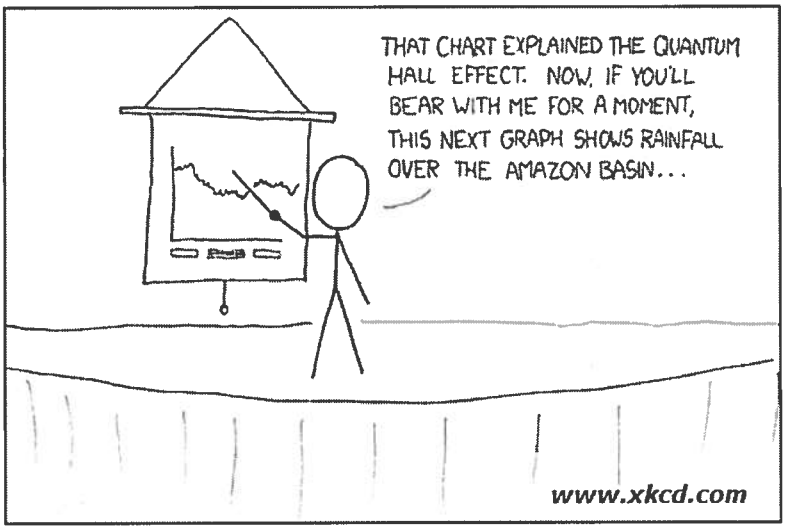
Instructor

Kevin Kelly
Brockman 326, 713.348.3565, kkelly@rice.edu

Prerequisites Sophomore-level understanding of physics, chemistry, mathematics

Times and Places

Office Hours: M 10-12 BRK 326, TThu 1-2:30pm Brockstein Pavilion, or appointment
Lectures: RAYZOR 106, MW 3:00-4:30pm *Owlspace:* Elec 571 001 F14


THAT CHART EXPLAINED THE QUANTUM HALL EFFECT. NOW, IF YOU'LL BEAR WITH ME FOR A MOMENT, THIS NEXT GRAPH SHOWS RAINFALL OVER THE AMAZON BASIN...
www.xkcd.com

IF YOU KEEP SAYING "BEAR WITH ME FOR A MOMENT", PEOPLE TAKE A WHILE TO FIGURE OUT THAT YOU'RE JUST SHOWING THEM RANDOM SLIDES.

Required Reading *Will be posted on the Owlspace website*

Grading

33% - Homework, Paper summaries, Quizzes
33% - Presentation
33% - Final paper
ALL assignments must be completed, or you will receive an incomplete.

Project

For the second half of the semester, each person will present a 20 minute talk and write an accompanying 7 to 10 page paper expanding on the topic in relation to the concepts discussed in the class.

Students with disabilities

Any student with a documented disability needing academic adjustments or anyone needing other accommodations is requested to speak with me during the first two weeks of class. All discussions will remain confidential. Students with disabilities should also contact Disabled Student Services in Ley Student Center.

{The information contained in the course syllabus may be subject to change with reasonable advance notice, as deemed appropriate by the instructor.}

Prof. Kelly's Zen of Knowledge

The challenge is that you want to learn what you know that you don't know, but since you don't know it you know nothing to relate it to in the knowledge you now possess. For what I know cannot simply be added to what you know since there is no union between my knowing and your knowing; and ergo, I can explain it to you but I cannot know it for you. Your knowledge begins with your perceptions, so everything you know is particular to you through your knowledge and cannot be perceived from my knowledge. Instead, I have to knowingly explain to you the things you already knew you knew but make it appear new instead of how you formerly knew it by placing it in a new context. In so doing you will now know something new and can relate it to what you previously knew so that you know now that you personally and truly gained new knowledge.

Course Topics

Digital Image Processing

A. Formation and acquisition
B. File formats and compression
C. Fourier Space
D. Filtering
E. Registration and feature tracking
F. Software (Photoshop,Matlab,UTHSCA ImageTool,NIHImage,GIMP, Gwyddion,WSXM)

Photon Image Sensors

A. Photodiodes
B. CCD/CMOS arrays
C. Photomultiplier tubes/Scintillation detectors
D. Spectrometers
E. Detector noise and sensitivity

Optical Microscopy

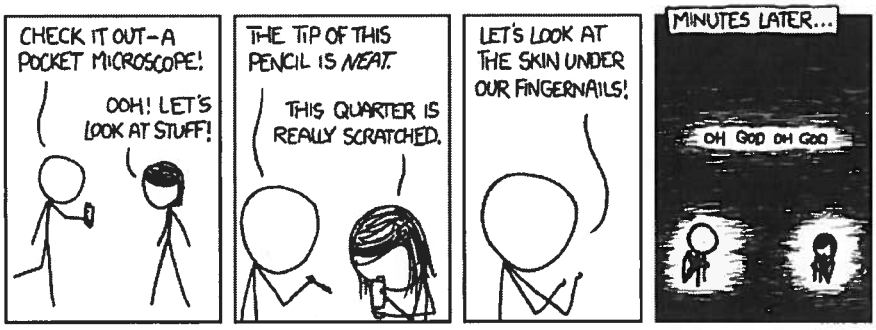
A. Electromagnetic wave equation & the diffraction limit
C. Far-field vs. near-field
D. Confocal and super resolution microscopy
E. Spectroscopy
F. Negative index materials and superlensing

Electron Microscopy

A. Electron optics
B. Scanning vs. transmission
C. Diffraction
D. Electron holography
E. Spectroscopy

Scanning Probe Microscopy

A. Basic operation
B. Electron tunneling
C. Force microscopy
D. Photon tunneling
E. Probe spectroscopy


CHECK IT OUT—A POCKET MICROSCOPE!
OOH! LET'S LOOK AT STUFF!
THE TIP OF THIS PENCIL IS NEAT.
THIS QUARTER IS REALLY SCRATCHED.
LET'S LOOK AT THE SKIN UNDER OUR FINGERNAILS!
MINUTES LATER...
OH GOD OH GOD

EXAMPLE RESEARCH PUBLICATIONS

(http://www.isiknowledge.com, http://scholar.google.com, http://www.researchgate.net)

Accounts of Chemical Research
ACS Nano
Advanced Materials
Applied Physics Letters
Biophysical Journal
Chemical Physics Letters
Chemistry of Materials
IEEE Transactions on Image Processing
Journal of the American Chemical Society
Journal of Applied Physics
Journal of Biomedical Optics
Journal of Crystal Growth
Journal of Electronic Imaging
Journal of Materials Research
Journal of Materials Science and Engineering B
Journal of Nanophotonics
JOSA A
Journal of Physical Chemistry A/B
Journal of Vacuum Science and Technology A/B
Langmuir
Materials Characterization
Materials Science and Engineering B
Microscopy Research and Technique
Nanoletters
Nature
Nature Methods
Nature Photonics
Nanotechnology
Optical Engineering
Optics Express
Optics Letters
Physica
Physical Review Letters
Physical Review B
Proceedings of the National Academy of Sciences
Progress in Surface Science
Review of Scientific Instruments
Scanning: Journal of Scanning Microscopies
Science
SIAM Journal of Imaging Science
Surface and Interface Analysis
Surface Science
Surface Science Reports
Synthetic Metals
Thin Solid Films
Ultramicroscopy